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FIVE YEARS OF COOPERATIVE RESEARCH
ON CONTROL OF THE CORN EARWORM
IN SWEET CORN



Agricultural Research Service
United States Department of Agriculture

States and Entomologists Participating in the
National Corn Earworm Experiments

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- California.--L. D. Anderson, Citrus Experiment Station, Riverside
(1954)
- Florida.--W. H. Thames, Jr., Everglades Agricultural Experiment
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- Georgia.--C. M. Beckham, Agricultural Experiment Station,
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ment Station, and G. W. Snedecor, of Iowa State College, gave valuable
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FIVE YEARS OF COOPERATIVE RESEARCH ON CONTROL OF THE CORN EARWORM IN SWEET CORN

By W. G. Eden, Alabama Agricultural Experiment Station,
and J. W. Ingram, Entomology Research Division

The corn earworm (Heliothis zea (Boddie)) has caused more damage to sweet corn than any other insect. It has also been the most difficult to control. Since DDT became available, good earworm control has been both possible and practicable, but the degree of control has varied by years and areas.

To determine the variation in control by areas, as a basis for control recommendations, a Federal-State cooperative project, called the National Corn Earworm Experiment, was begun in 1952 and conducted annually through 1956. The following phases of earworm control were investigated: (1) effectiveness of mineral oils when used with DDT (1952), (2) effects of different dosages of DDT with and without mineral oil (1953 and 1954), (3) effects of timing and number of applications of DDT-mineral oil sprays (1955), and (4) influence of intervals between applications of DDT sprays (1956).

General Procedure

The experiments were conducted as nearly as possible on a uniform basis for any given year. Except for the first year, the same variety (Aristogold Bantam) and seed source were used throughout the experiments. The oils were from the same sources, and DDT from the same source was used in all locations in the first 3 years. In the last 2 years the DDT was provided by the cooperating entomologists and was of various brands.

The materials were supplied by the following companies:^{1/}

Sweet corn seed	Micheal-Leonard Co.
Mineral oils:	
Carnation	L. Sonneborn Sons, Inc.
Sovaspray No. 1	Sacony Vacuum Co.
Superla 13, Premier White,	
Mineral Seal	Standard Oil Co.
DDT	John Powell Chemical Co.
	Geigy Chemical Co.
Emulsifier, Atlox G-2090	Atlas Powder Co.

^{1/} The inclusion of the names of these companies does not imply the Department's endorsement of their products.

Certain general procedures were common to all experiments over the 5-year period. All sprays were applied by fixed-boom, high-clearance power equipment, or such conditions were simulated. The fixed-boom had four flat fan nozzles, two for each side of the row, which directed the spray into the ear region of the stalks. Sprays were usually applied at 20 to 25 gallons per acre at a pressure of about 100 p.s.i. All sprays were emulsions and were prepared from 25 percent DDT emulsifiable concentrates. Each plot consisted of four rows of corn about 100 feet long. Treatments were replicated four times in randomized blocks. Unless otherwise indicated, from three to six applications were made at intervals of 2-3 days beginning when the first silks appeared. Records of worm-free ears were taken from the primary ears on the two inside rows.

The data were first analyzed by individual locations, and then a combined analysis over all participating locations was calculated. Conclusions were drawn each year from the combined analysis. The analyses were made on angles (angle = $\arcsin \sqrt{\text{percentage of worm-free ears}}$).

Experiment with DDT Plus Mineral Oils

The results of this experiment are presented in table 1. The degree of infestation varied significantly with the location. The average percentage of worm-free ears ranged from 34.9 in Texas to 89.3 in South Carolina.

The effects of the treatments in reducing earworm infestation on a national basis were highly significant. However, there were highly significant variations in the order of effectiveness by locations. All spray treatments resulted in significantly more worm-free ears than no treatment. The use of DDT alone resulted in 58.1 percent of worm-free ears, and the unsprayed corn had 25.7 percent. The addition of Superla 13, Premier White, and Carnation mineral oils to the DDT resulted in significantly more worm-free ears than DDT alone. The increase from Premier White was highly significant. There were no significant increases from the additions of Sovaspray No. 1 and Mineral Seal oils.

The relations between the characteristics of the mineral oils and the percentage of worm-free ears are presented in table 2. The viscosities of the oils ranged from 42.5 to 130.0 seconds Saybolt and the gravities from 32.9 to 37.4 degrees API, but there was no correlation between either viscosity or gravity and earworm control. The unsulfonated residues ranged from 92.0 to 100.0 percent, and the earworm control increased accordingly.

The results of this experiment revealed that, nationally, the addition of mineral oil to DDT significantly increased earworm control. The average increase was 11.5 percent of worm-free ears.

Experiments with Different Dosages of DDT with and without Oil

The results of these experiments are presented in table 3. The mean infestations for all treatments varied significantly from location to location in both years. The percent of worm-free ears ranged from 45.4 in South Carolina to 70.7 in Alabama in 1953, and from 36.6 in Ohio to 92.0 in North Carolina in 1954.

The treatments were highly significant in reducing the infestation in both years. The average effect of adding oil to the DDT was highly significant, although the effect was not always highly significant at a particular rate of DDT. Although the control did not increase significantly with each 1/2-pound increment of DDT, the trend was highly significant, both with and without mineral oil (figure 1). DDT at 2 1/2 pounds per acre without mineral oil resulted in approximately the same control as 1 1/2 pounds with 1 3/4 gallons of mineral oil. Although the degree of control varied with the location, the same trend resulted from the treatments at each location.

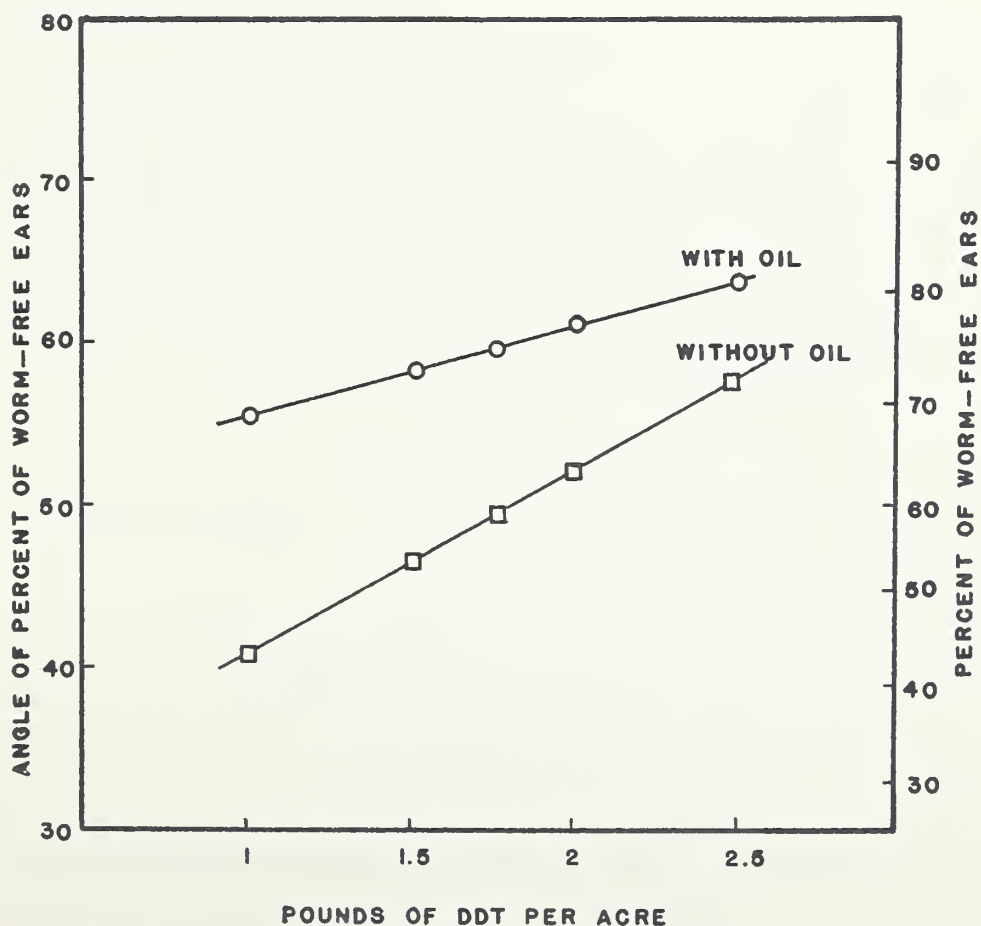


Figure 1.--Regressions of worm-free ears on dosages of DDT with and without mineral oil, 1954.

Number and Timing of Applications of DDT-Mineral Oil Sprays

The results of this experiment are given in table 4. The earworm infestations varied significantly between locations. The mean percentage of worm-free ears ranged from 39.3 at Clemson to 97.3 in Louisiana. Although all spray treatments were highly effective, the effects varied significantly with the location. Time of beginning the spray program, whether it was the first or second day after the first silks appeared, had no effect. The major factor appeared to be the interval between spray applications. The most effective control resulted from six treatments at 2-day intervals, and the least effective from four treatments at 3-day intervals.

Intervals Between DDT Sprays

The results of this experiment are presented in table 5. The earworm infestations in both the untreated and treated plots varied significantly with the location. All spray treatments were significantly effective. When the interval between applications was constant throughout the 14-day spray period, which began the first day after the first silks appeared, the control was inversely proportional to the length of the interval. Increasing the interval between sprays during either half of the protection period resulted in a highly significant trend of reduction in control. However, a close-interval spray schedule was more important during the first part of the protection period than during the latter. As in previous experiments, approximately the same earworm control resulted from the use of 1 1/2 pounds of DDT plus 1 3/4 gallons of mineral oil per acre as from 2 1/2 pounds of DDT alone when the sprays were applied at 2-day intervals.

General Conclusions

1. Corn earworm infestations in sweet corn varied considerably in different locations and years.
2. Every DDT or DDT-mineral oil spray program used during the 5-year period significantly reduced the infestation.
3. The effectiveness of sprays frequently varied from location to location.
4. The addition of mineral oil to DDT increased the earworm control.

5. There was no correlation between the viscosity or specific gravity of the mineral oil and earworm control when used with DDT.

6. There was a positive correlation between the amount of unsulfonated residue in the mineral oil and earworm control.

7. Increasing the rate of DDT by 1/2-pound increments, either with or without mineral oil, from 1 to 2 1/2 pounds per acre gave a significant increase in control.

8. DDT at 2 1/2 pounds per acre gave approximately the same control as 1 1/2 pounds with 1 3/4 gallons of mineral oil.

9. When sweet corn was sprayed six times at 2-day intervals with 2 pounds of DDT plus 1 gallon of mineral oil per acre, there was no significant difference in control when the spray program was begun the first or the second day after the first silks appeared.

10. When the interval between applications was constant throughout a 14-day spray period, the control was inversely proportional to the length of the interval.

11. Increasing the interval between applications in either half of the spray period, when followed or preceded by daily spraying, reduced earworm control below that obtained with daily spraying.

12. A close-interval spray program was more important during the first part of the protection period than during the latter part.

Table 1.--Percentage of worm-free ears after treatment with DDT plus different kinds of mineral oils in different locations, 1952. Dosage 1 1/2 pounds of DDT plus 1 3/4 gallons of oil per acre.

Location	Untreated check	DDT only	DDT plus oil				Location mean
			Sovaspray No. 1	Superla 13	Premier White	Mineral Seal	Carnation
Alabama	2.0	52.0	70.3	73.3	75.8	58.8	74.5
Georgia	32.0	50.0	56.0	55.0	77.0	60.0	46.0
Illinois	14.0	63.0	66.0	86.0	79.0	76.0	86.0
Maryland	9.9	69.7	74.0	78.3	78.8	73.7	75.7
North Carolina	47.0	55.5	55.3	67.5	68.5	62.5	62.0
Pennsylvania	38.7	66.7	53.6	79.4	74.8	75.6	81.5
South Carolina	78.4	91.5	90.6	94.6	92.4	86.8	90.8
Texas	0.0	22.0	36.0	37.0	49.0	25.0	75.0
Virginia	9.5	52.0	68.0	73.0	71.0	58.5	55.5
Mean	25.7	58.1	63.4	71.6	74.0	64.1	71.9
Mean angle ^{1/}	26.82	50.10	53.43	58.83	60.16	53.73	58.97
							--

^{1/} LSD (5%) 7.06.

Table 2.--Effect of characteristics of mineral oils on the percentage of worm-free ears of sweet corn sprayed with DDT plus oil, 1952

Oil	Viscosity at 100° F. (Saybolt seconds)	Unsulfonated residue (percent)	Gravity (°API)	Worm-free ears	
				Percent	Angle 1/
Sovaspray No. 1	60.0	92.0	35.9	63.4	53.43
Superla 13	130.0	100.0	32.9	71.6	58.83
Premier White	75.5	99.6	35.1	74.0	60.16
Mineral Seal	42.5	93.8	37.4	64.1	53.73
Carnation	67-72	97+	37.0	71.9	58.97

1/ LSD (5%) 5.12.

Table 3.--Percentages of worm-free ears after treatment with different dosages of DDT per acre, with and without mineral oil (13/4 gallons), 1953 and 1954.

Location	Untreated check	DDT 1 lb.		DDT 1 1/2 lb.		DDT 2 lb.		DDT 2 1/2 lb.		Location mean
		Oil	No oil	Oil	No oil	Oil	No oil	Oil	No oil	
1953 Experiment										
Alabama	13.5	82.0	51.8	90.9	73.7	88.0	80.3	--	85.3	70.7
Maryland	3.6	64.5	41.3	72.8	60.8	76.1	64.2	--	71.1	56.8
Ohio	3.5	78.5	62.5	86.5	77.0	91.0	79.0	--	86.5	70.6
South Carolina	1.4	58.4	27.5	56.2	56.0	60.6	51.8	--	51.6	45.4
Mean	3.6	64.5	41.3	72.8	60.8	76.1	64.2	--	71.1	56.8
Mean angle ^{1/}	10.99	53.41	39.38	58.56	51.26	60.75	53.27	--	57.50	--
1954 Experiment										
Alabama	0	58.8	17.5	74.5	42.8	81.0	53.3	86.8	64.5	53.2
California	0	59.0	7.0	62.0	10.0	74.0	19.0	73.0	45.0	38.8
Florida										
Central	0	62.0	31.0	68.0	48.0	57.0	55.0	66.0	69.0	50.7
Everglades	4.1	84.7	79.4	88.0	82.4	92.6	92.5	--	--	74.8
Kentucky	41.0	78.0	72.0	90.0	73.0	83.0	82.0	87.0	79.0	76.1
Maryland	36.0	68.2	--	69.1	60.2	79.7	68.1	79.0	79.3	67.4
North Carolina	73.0	97.0	92.0	92.0	94.0	97.0	93.0	97.0	93.0	92.0
Ohio	8.5	40.0	25.0	44.5	28.0	50.0	42.0	52.5	39.0	36.6
South Carolina	1.0	37.0	15.5	45.5	32.5	54.0	37.0	61.0	52.5	37.3
Mean	18.2	65.0	42.4	70.4	52.3	74.3	60.2	75.3	65.8	58.2
Mean angle ^{2/}	18.30	55.41	40.90	58.47	46.78	61.45	52.30	63.70	57.40	--

Table 4.--Percentages of worm-free ears in sweet corn following DDT-oil sprays applied at different intervals beginning on the first and second days after the first silks appeared, 1955. Dosage 2 pounds of DDT plus 1 gallon of oil per acre.

Location	Untreated check	First day				Second day		Location mean
		2-day interval		3-day interval		2-day interval	3-day interval	
		6 treat-ments	5 treat-ments	5 treat-ments	4 treat-ments			
Alabama	11.0	90.5	91.8	81.0	77.8	76.8	74.5	71.9
Florida	10.0	75.0	86.0	69.5	80.0	90.0	73.0	69.1
Kentucky	27.0	96.0	91.0	90.0	77.0	89.0	77.0	78.1
Louisiana	88.0	98.0	100.0	99.0	99.0	99.0	98.0	97.3
Mississippi	0	72.5	59.0	65.5	67.8	75.0	45.0	55.0
North Carolina	2.0	92.0	92.0	94.0	91.0	90.0	85.0	78.0
South Carolina								
Clemson ^{1/}	4.0	59.5	31.0	49.5	34.5	61.5	35.0	39.3
Pee Dee ^{2/}	1.0	78.0	72.5	50.0	54.0	80.0	51.0	55.2
Virginia	23.0	96.0	93.0	93.0	92.0	99.0	85.0	83.0
Mean	18.4	84.2	79.6	76.8	74.8	84.5	69.3	69.7
Mean angle ^{2/}	20.60	69.70	66.92	64.54	62.43	69.88	58.06	--

^{1/} All plots except those receiving 5 treatments at 3-day intervals beginning the first day after silks appeared received one more application than indicated because of delayed maturity of corn.

^{2/} LSD (5%) 6.81.

Table 5.--Percentages of worm-free ears in sweet corn following DDT sprays applied at various intervals during a 14-day period beginning the first day after the first silks appeared, 1956.
Dosage 2 1/2 pounds of DDT per acre except as otherwise indicated.

Location	Untreated check	1-day interval for entire period	1-day interval for 7 days and thereafter-		2-day interval for entire period ^{1/}	2-day interval for 8-days and 1-day thereafter	3-day interval for entire period	3-day interval for 9 days and 1-day thereafter	Location mean
			2-day	3-day					
Alabama	1.0	96.5	95.5	91.8	84.5 (91.0)	81.8	65.6	52.5	73.4
Florida	0.5	98.5	96.7	94.2	89.9 (96.6)	98.6	91.4	95.9	84.7
Maryland	9.7	96.3	89.0	78.7	85.5 (84.5)	90.6	76.8	83.0	77.1
Mississippi	10.5	95.8	94.0	92.0	91.5 (89.0)	94.0	73.5	70.8	79.0
North Carolina	8.0	99.0	95.0	96.0	96.0 (80.0)	100.0	89.0	77.0	82.2
South Carolina									
Clemson	2.0	93.5	93.0	82.5	65.0 (87.0)	72.0	46.5	43.5	65.0
Pee Dee	6.0	93.0	89.0	78.0	74.0 (81.0)	71.5	61.5	56.5	67.8
Mean	5.4	96.1	93.2	87.6	83.8 (87.0)	86.9	72.0	68.5	75.6
Mean angle ^{2/}	11.31	80.45	75.86	71.01	68.24 (70.72)	72.42	59.41	57.22	--

^{1/} Figures in parentheses are results of treatments with 1 1/2 pounds of DDT plus 1 3/4 gallons of mineral oil.

^{2/} LSD (5%) 6.75.

